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Agricultural Memorandum No 955

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Weather and the growth of oilseed rape - a summary of recent work and application to the assessment of yields in UK

Agricultural Memorandum 543 gave a brief account of weather and OSR, but since then work at Sutton Bonington (Mendham, Shipway and Scott, 1981) has produced many more results. This memorandum summarises the findings on the effects of weather on OSR and applies the results to support the belief that OSR yields in northern UK are higher than those in the south.

Summary of the effects of weather on OSR

Development

The crop is sown in August and September, and because the effects of weather vary with sowing date it is convenient to use the terminology, "early sown" for crops sown before mid September and "late sown" for crops sown after that. OSR appears to have a threshold temperature for leaf growth of about 5°C with the rate of appearance and expansion of leaves controlled by temperature conditions. The first cold spell in late autumn seems to induce a form of dormancy, and leaf growth is very slow from December to February. Growth begins again in March as temperatures and radiation levels increase. The shape of the LAI curves for early and late sown crops are shown in figure 1. The early sown crop commences rapid growth in September and establishes a LAI of 2 or 3 by the end of November. Some leaf loss takes place in winter due to senescence or pigeons, but more leaves grow in March and April. The late sown crop remains small with a low LAI during the winter, but there is a spring peak in leaf area production. Flowering starts at the end of April and reaches a peak approximately coincident with the peak in leaf area production. The pod hulls start to grown at the time when stem extension ceases. In the first weeks of June the seeds start to grow when the growth of the pod hulls is complete. Figure 2 summarises the growth stages.

The development of pod hulls and seeds is controlled by temperature. Figure 3 shows the relation for the period flowering to harvest. For the temperature range 12 to 17°C the relation between development rate and temperature is linear. The relation for seed growth is shown in figure 4, and there is a linear relation between development rate and (mean maximum) temperature.

Yield

a) Late sown crops

The duration of the time (and hence the radiation interception) from the resumption of spring growth and flowering was found to be very important in the yield formation of late sown crops. It was found that the top dry weight at flowering was a good predictor of seed yield (figure 5). Since pod bearing branches grow from the leaf axils, then the more leaves that can grow in spring imply a higher number of pods,

and so higher yields. In turn the top dry weight at full flower is related to the radiation interception from the resumption of spring growth to the time of full flower (figure 6). This implies that radiation interception in spring can be used to estimate the seed yield of late sown crops.

b) Early sown crops

Early sown crops showed far less yield variation than late sown. Mendham et al conclude that early sown crops tend to produce an inefficient canopy. A huge number of pods are formed, but since the dense mass of flowers can reflect 40-45% of the short wave radiation falling upon it, a lot of pods are aborted in the lower parts of the canopy. Even so a large number of pods remain; there is intense competition for assimilate during seed growth with the result that seed number per pod is very low. By contrast, late sown crops have fewer pods, a more open canopy, and more seeds per pod. Cool, bright weather during pod and seed growth will ensure the greatest retention of pods and seeds.

Comparison of Weather Conditions between North and South England in relation to OSR growth and yield

Calculations are made for High Mowthorpe (Yorkshire Wolds) and Hurley (Berkshire, Thames Valley) for the years 1976 to 1979.

Late sown crops

Before any calculations could be done it was necessary to estimate the date of full flower at Hurley and High Mowthorpe. The dates of 50% flowering at Sutton Bonington were obtained from Mendham et al and the accumulated temperature above 6°C was found from sowing to 50% flowering. 6°C rather than 5°C was used because data were readily available. Figure 7 shows the accumulated temperature total plotted against sowing date. There is a steady reduction from 700°C days for early sown crops to about 400°C days for late sown. The farm reports from High Mowthorpe EHF were used to support (or modify) the dates found by this method. One major weakness of this technique is that the dates of 50% flowering tend to be later for the early sown crops than for late sown. Observations of crops tend to show the reverse. In addition, this effect is enhanced at the cooler site (High Mowthorpe). This could possibly imply that day-length is more important than temperature in determining flowering date, or that a low temperature adaptation occurs at cooler sites.

Method of estimating yield

1) Accumulated temperature above 6°C were used to find the date of start of spring growth and the date of 50% flowering.

2) Leaf area index curves were estimated. The peak LAI was assumed to be 2 for all crops and occurred 7 days after the 50% flowering date.

3) Weekly radiation totals for Hurley and High Mowthorpe were estimated from sunshine hours, from the date of the start of spring growth to the date of 50% flowering.

4) The fraction of radiation absorbed was estimated from Beer's Law as $(1 - \exp(-kL))$ L = weekly mean LAI, k = extinction coefficient = 0.6 from Mendham et al.

5) Total intercepted radiation was found. Figures 5 and 6 were then used to find the seed yield.

Figure 8 shows the accumulated temperature and LAI curves in one season for the 2 sites. Note that in all the years an early sowing is taken as 25 August, and a late sowing as 10 October. The results for the years 1976 to 1979 are in table 1. From the table it is seen that in 3 years out of the 4 the calculated 50% flowering date for late sowings at High Mowthorpe fits into the observations of flowering fairly well. In 1977 the calculated date (26 June) is far later than the observations would imply, and an estimated date of 4 June is used instead (called L' in figure 8).

Table 2 Yield (t/ha) for late sowings

	1976	1977	1978	1979
Hurley	2.0	2.4	1.7	1.5
High Mowthorpe	2.8	2.8	2.2	1.7

The estimated yields at the 2 sites are in table 2. The overall yield level is rather low because these figures refer to late sowings only and are based upon cv Victor which is lower yielding than more modern varieties. In each year yields are higher at the northern site. This is because cooler temperatures delayed flowering and as a result light interception was at its maximum later in Spring when the total amount of radiation was higher.

Early Sown Crops

Cool conditions after flowering delay senescence and allows more radiation to be absorbed. The maps show the variation of mean temperature across UK in May and June. The arable areas of north east England and eastern Scotland are the coolest arable areas in UK. For example Yorkshire is about 1.0°C cooler in May and 1.5°C cooler in June than areas in the Thames Valley. These differences increase to 2.0°C and 2.5°C for the coastal strip between Newcastle and Berwick. Figure 3 shows that at 15°C about 69 days are available between flowering and harvest; at 13°C another 16 days are available to intercept radiation.

Summary

Detail of the yield calculation given above may be incorrect, but there seem to be good climatic reasons why yields of OSR should be higher in north UK.

1) Cooler temperatures in Autumn and Spring delay flowering so that the greatest radiation interception will occur when radiation levels are higher.

2) Cooler temperatures after flowering slow down development and senescence, and allows more radiation to be absorbed.

The highest yields of OSR in Britain should be obtained in Tyne and Wear, Northumberland, and the arable areas of east Scotland.

Reference

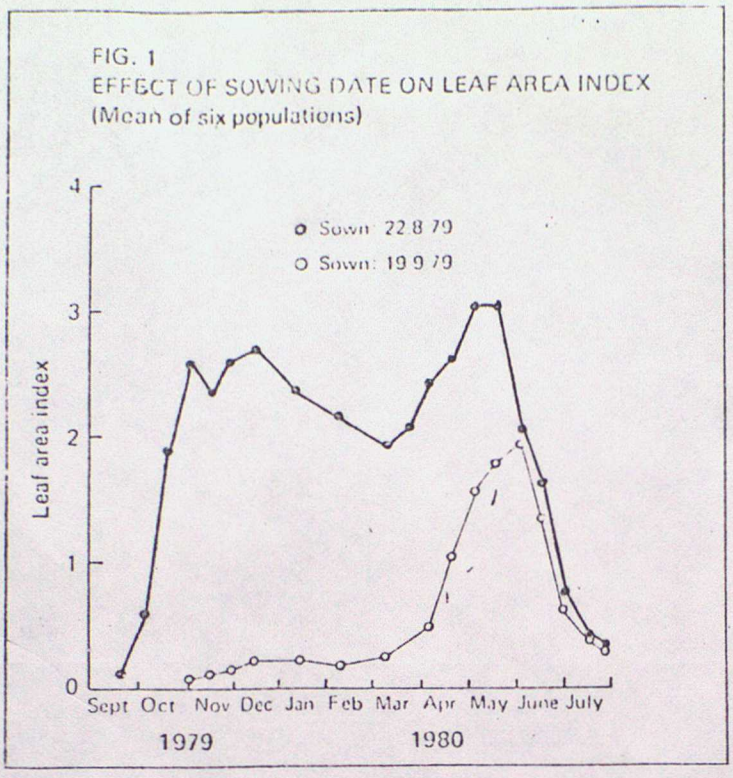
Mendham, N J, Shipway, P A, Scott, R K (1981). The effects of delayed sowing and weather on growth, development and yield of winter oil-seed rape (Brassica napus). J Agric Sci, Camb. 96, 389-416.

Harrogate, September 1982.

Table 1. Dates of start of spring and of 50% flowering

	Year		1976	1977	1978	1979
High Mowthorpe EHF	Start of Spring		27/3	1/3	25/2	7/4
	50% flowering date	By accumulated temperature	7/6 (late sown) 8/6 (early sown)	26/6 (late) 1/7 (early)	4/6 (late) 15/6 (early)	3/6 (late) 8/6 (early)
		Observations*	18/5 "yellow bud" 10/6 "full flower"	18/5"early flower" 21/6 "flowering $\frac{3}{4}$ complete"	23/5 "40% in flower (9 Sept sown)" "20% in flower (20 Sept sown)" "Not in flower (October sown)"	26-29/5 "flowering commenced"
		Date used in calculations	7/6	4/6	4/6	3/6
Hurley	Start of Spring		24/2	25/2	25/2	24/2
	50% flowering date	By accumulated temperature	5/5 (late) 20/4 (early)	18/5 (late) 10/5 (early)	1/5 (late) 2/5 (early)	25/4 (late) 19/4 (early)

* From crop observations at High Mowthorpe EHF kindly supplied by the farm director.



(Figure 1 is from "Oilseed Rape Pointers" E.J. Evans, Arable Farming, May 1981)

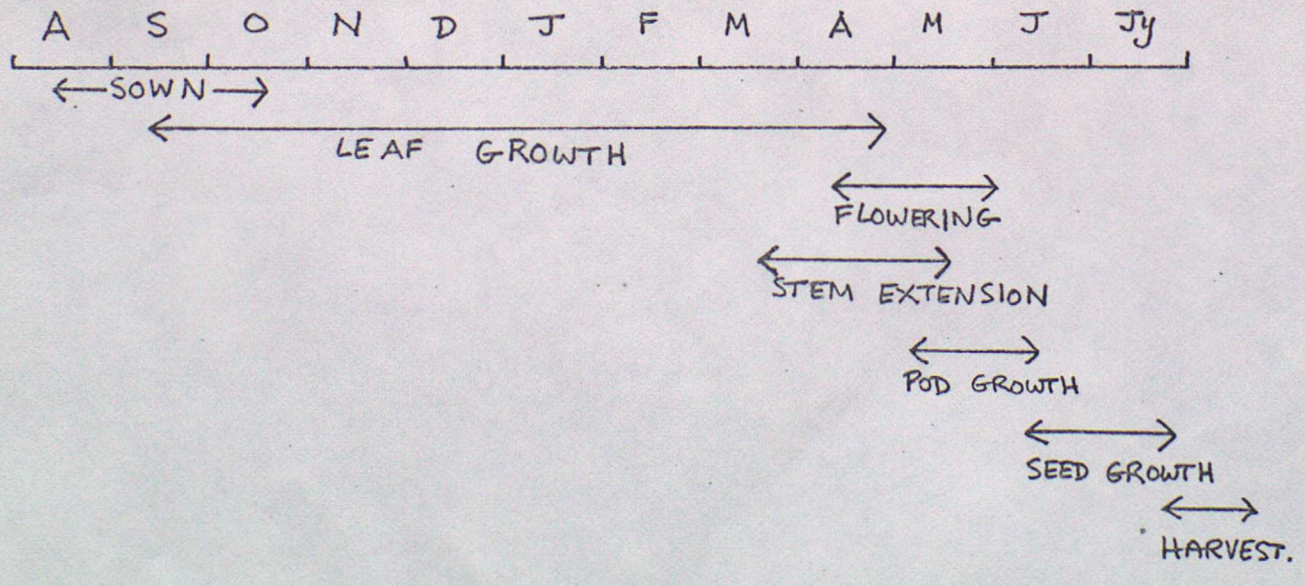


Figure 2. Growth stages for oil-seed rape.

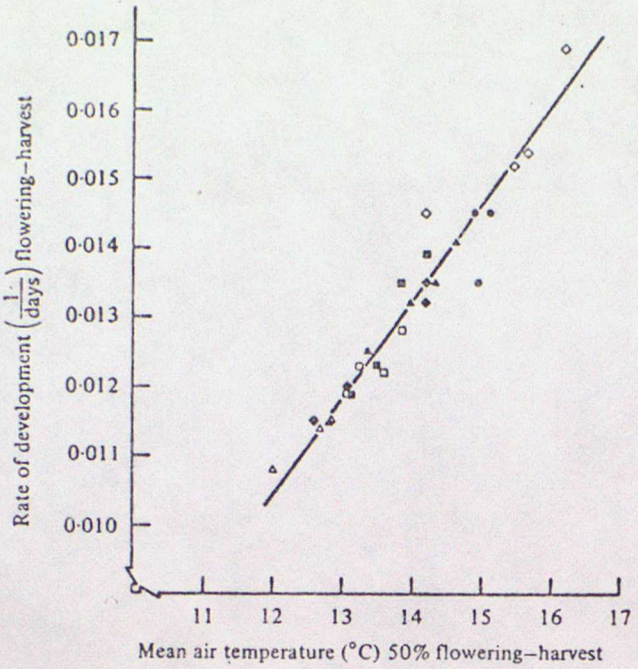


Fig. 3. The relationship between mean air temperature and the rate of development (reciprocal of number of days) from 50 % flowering to final harvest of crops sown in: ●, 1969–70; △, 1971–2; ▲, 1972–3; □, 1973–4; ■, 1974–5; ◇, 1975–6; ◆, 1976–7. $y = 0{\cdot}0014x - 0{\cdot}0059$, $r^2 = 0{\cdot}96$.

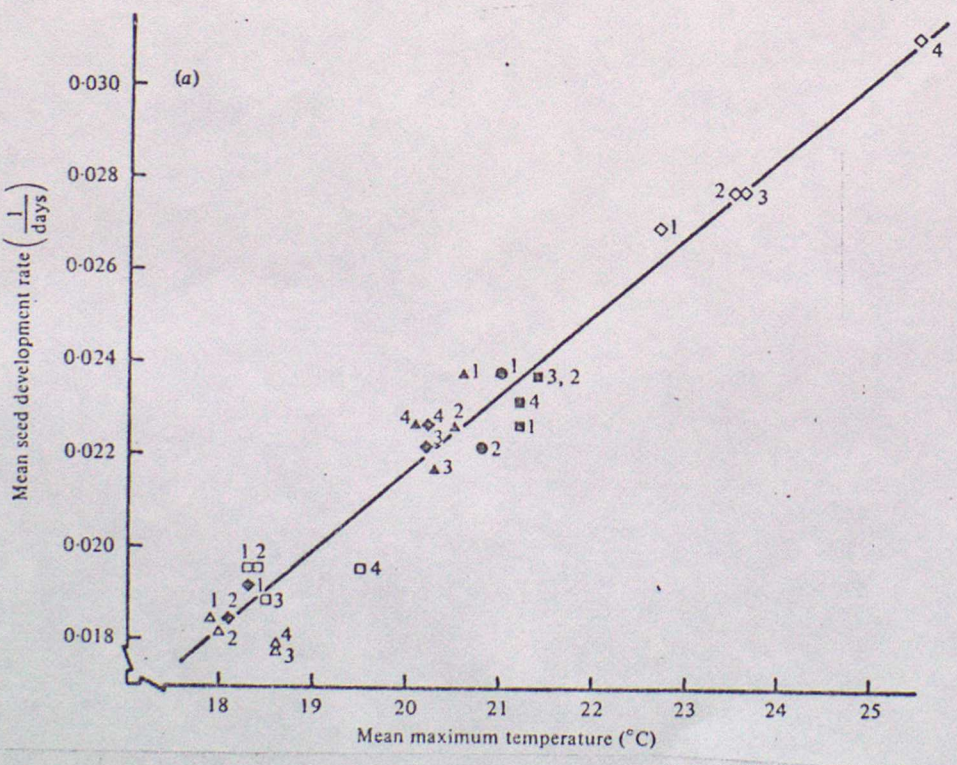


Fig. 4. (a) The relationship between mean maximum temperature over the seed growth phase, and the rate of seed development (reciprocal of days duration). $y = 0{\cdot}00172x - 0{\cdot}0128$, $r^2 = 0{\cdot}96$.

●, indicates 1969–70; △, 1971–2; ▲, 1972–3; □, 1973–4; ■, 1974–5; ◇, 1975–6; ◆, 1976–7. 1–4 indicates sowings.

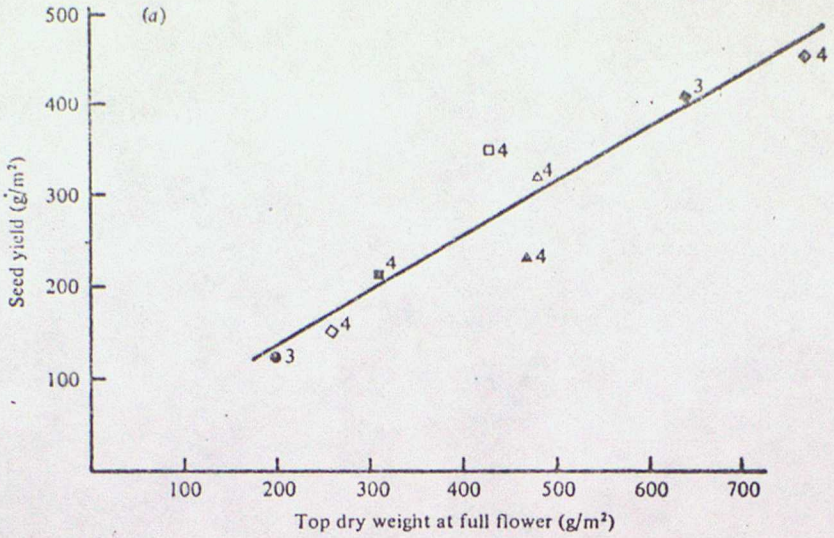


Fig. 5. The relationship between crop size at 'full flower' (50 % flowering + 7 days) and seed yield in (*a*) late sowings (October–November)

, in: ●, 1969–70; △, 1971–2; ▲, 1972–3; □, 1973–4; ■, 1974–5; ◇, 1975–6; ◆, 1976–7. Numbers indicate order of sowings 1–4.

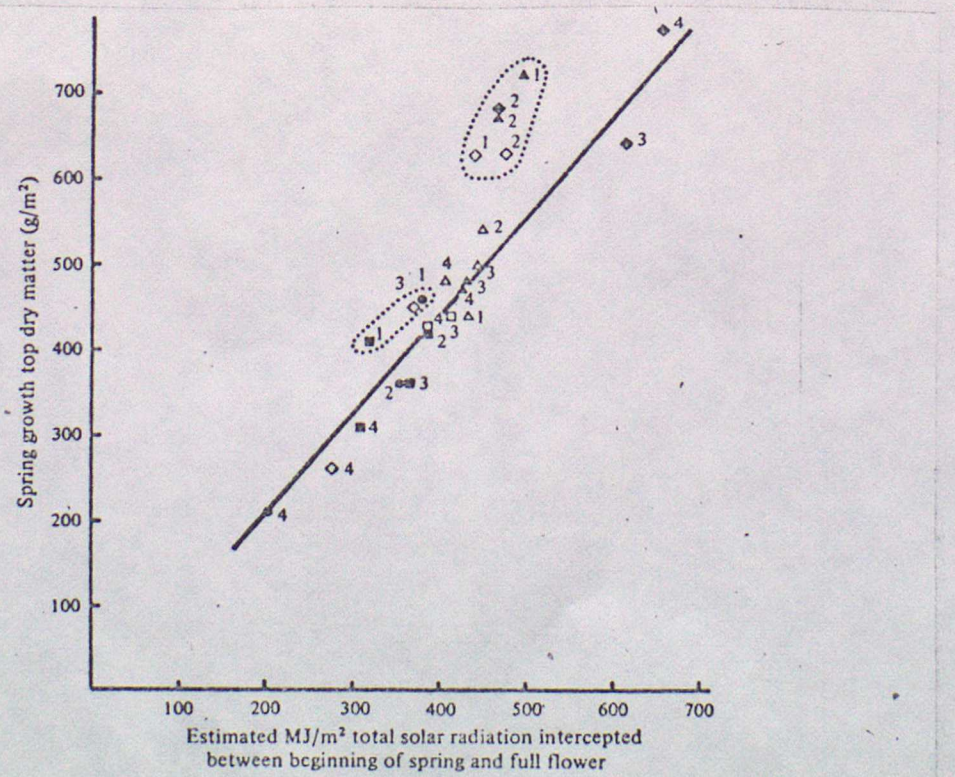


Fig. 6 The relationship between estimates of intercepted solar radiation and crop growth between the beginning of spring and full flower in: ●, 1969–70; △, 1971–2; ▲, 1972–3; □, 1973–4; ■, 1974–5; ◇, 1975–6; ◆, 1976–7. Nos 1–4 indicate sowings. ——, Regression line fitted to 3rd and 4th sowings: $y = 1{\cdot}16x - 28{\cdot}2$, $r^2 = 0{\cdot}91$. Divergent early sowings circled

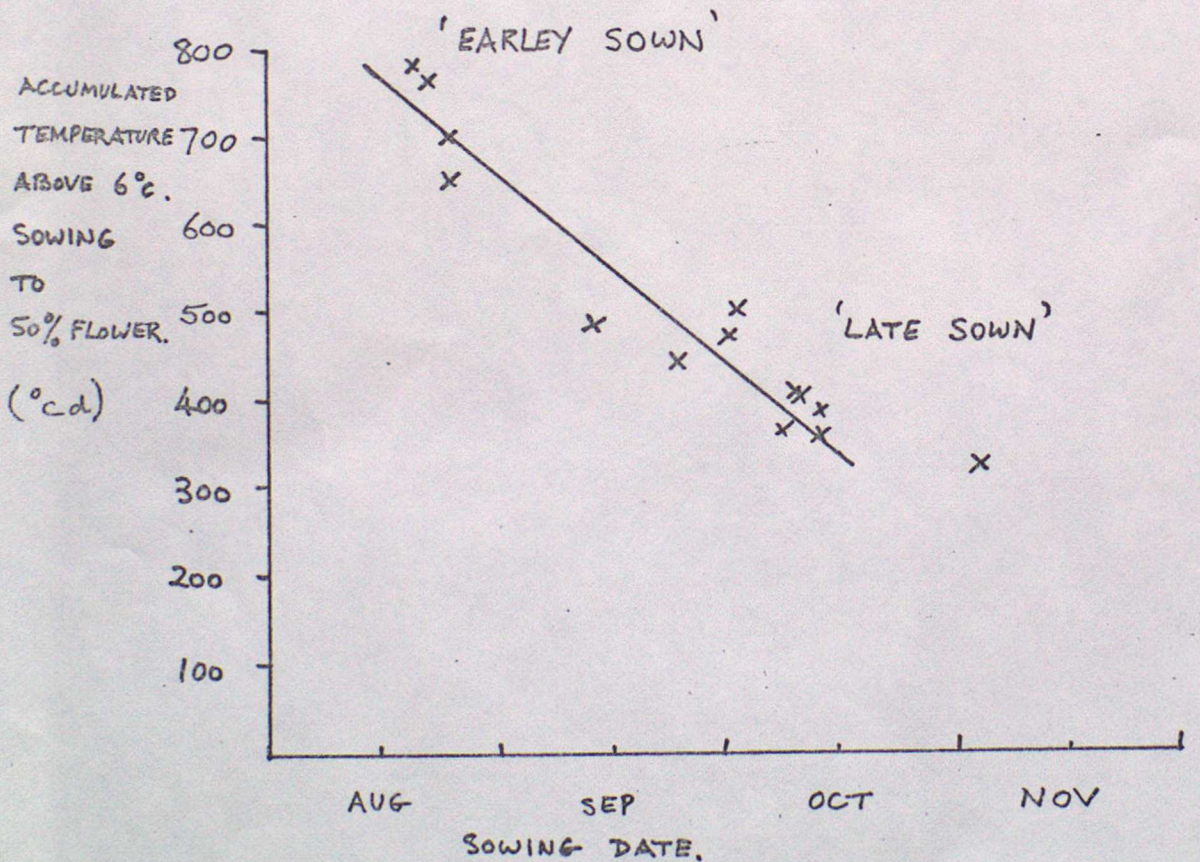
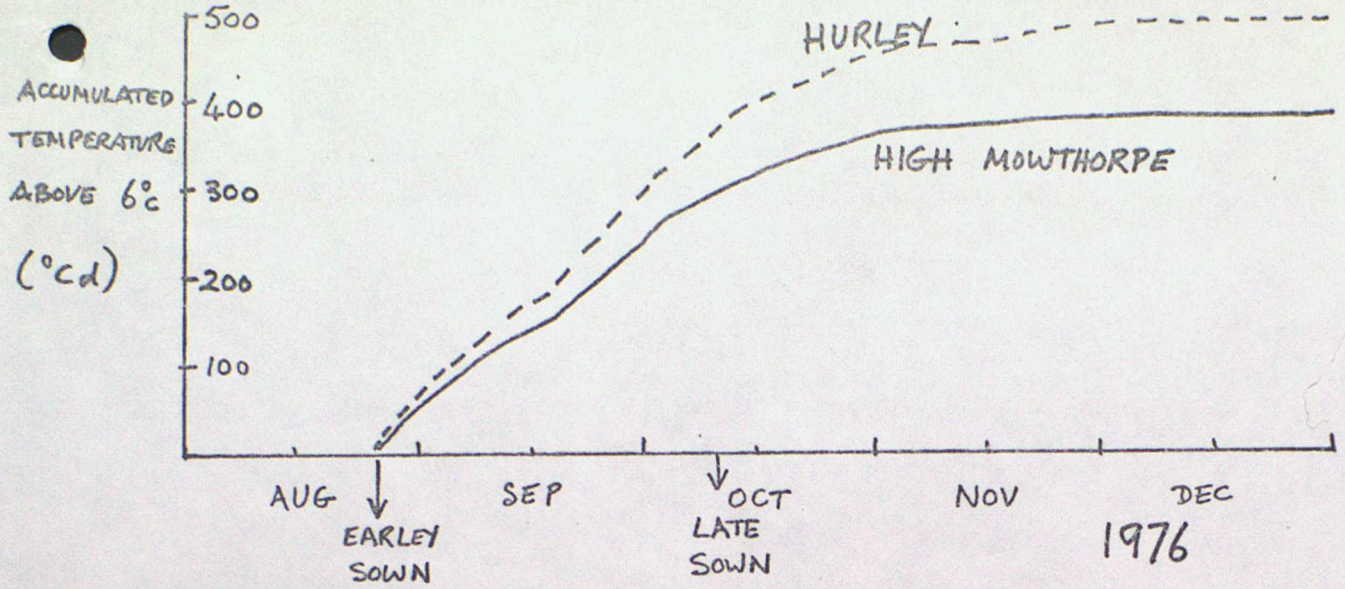
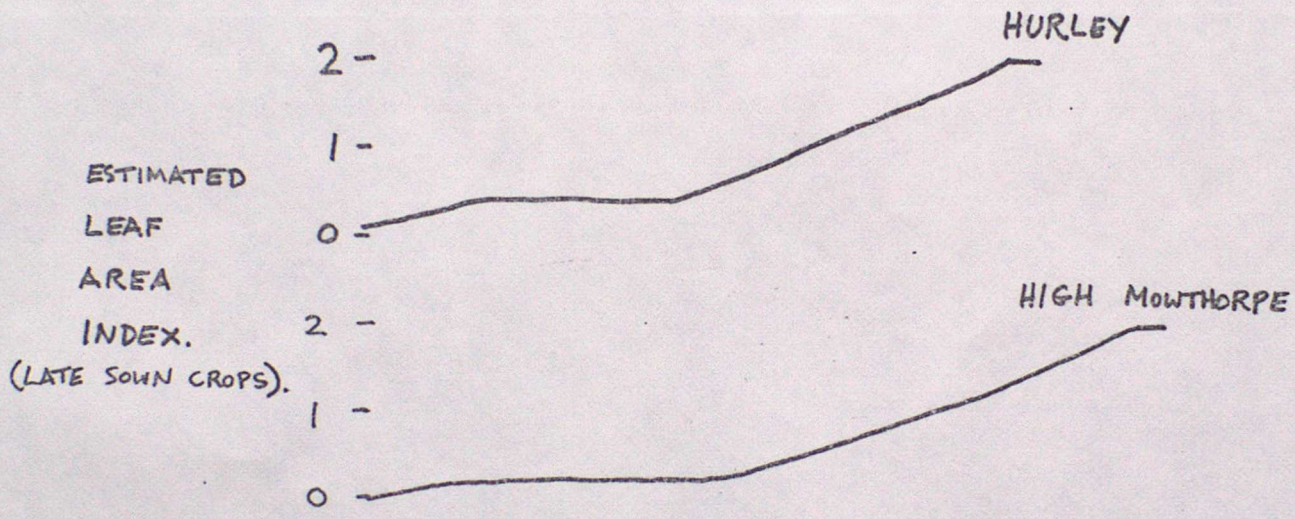


FIG. 7. ACCUMULATED TEMPERATURE ABOVE BASE 6°C AND SOWING DATE FOR OILSEED RAPE CV. VICTOR AT SUTTON BONINGTON.





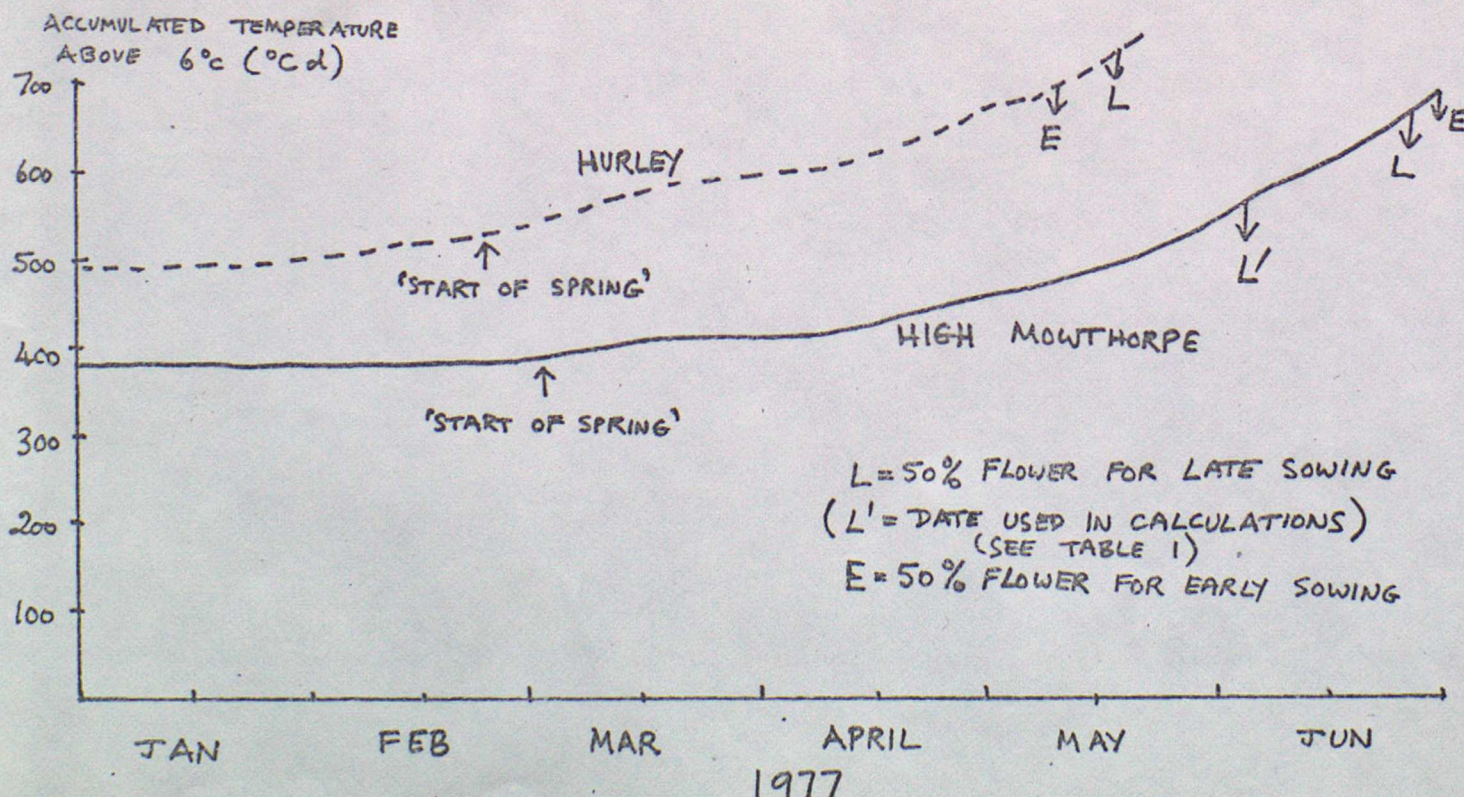


FIG. 8. ACCUMULATED TEMPERATURE AND ESTIMATED LEAF AREA INDEX AT HURLEY AND HIGH MOWTHORPE IN 1976/1977.

Figure 1.31

Mean Daily Temperature °C 1941-70 MAY

Reduced to Mean Sea Level
0·6°C/100 metres

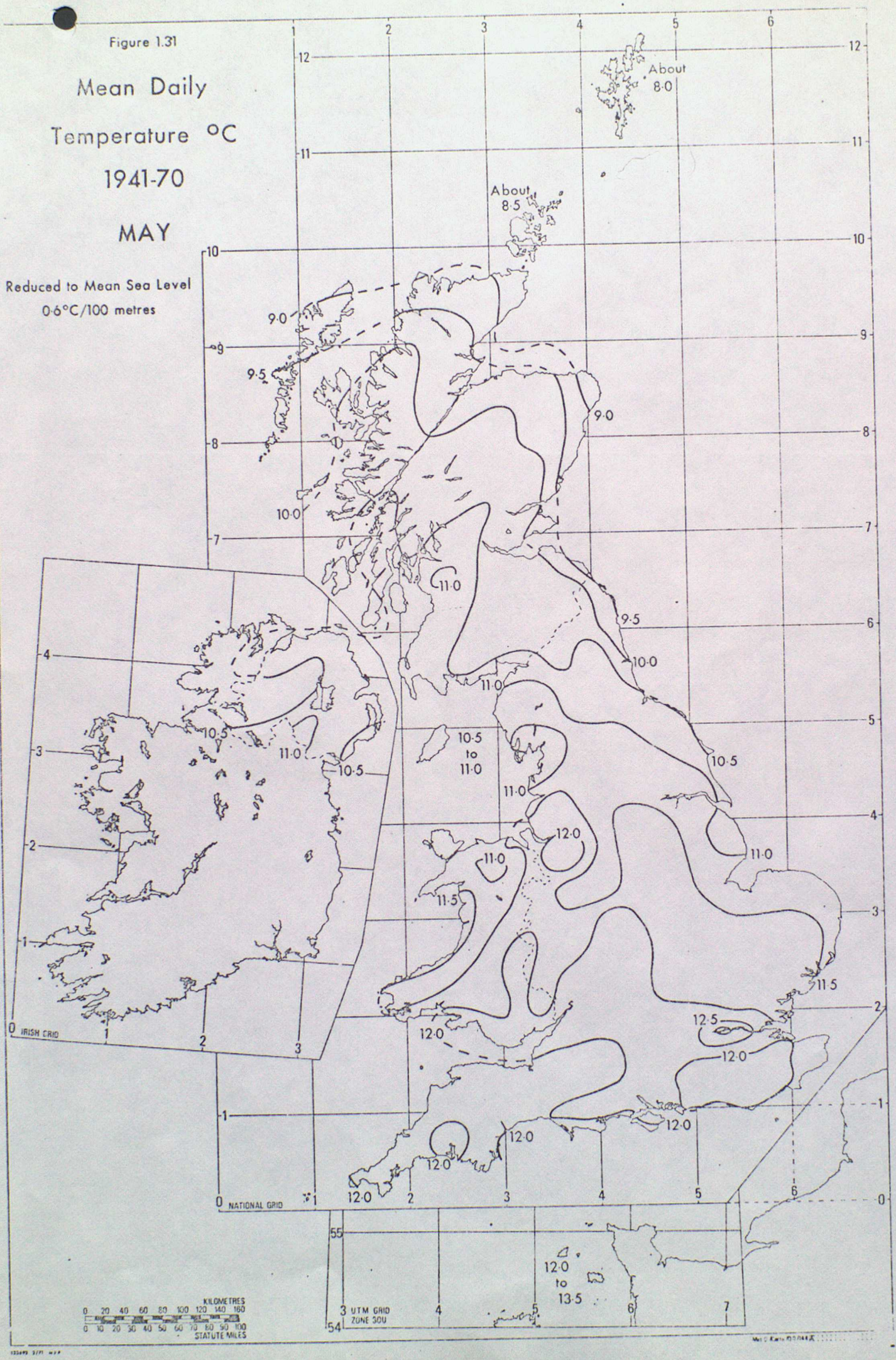


Figure. 1.32

Mean Daily Temperature °C 1941-70 JUNE

Reduced to Mean Sea Level
0·6°C/100 metres